LOOK ACADEMIC PUBLISHERS
OPEN ACCESS

INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION
2016, VOL. 11, NO. 15, 7515-7534

The Economic Efficiency of European Football Clubs - Data Envelopment Analysis (DEA) Approach

Aleksey V. Pyatunin[a], Angelina B. Vishnyakova[a], Natalia L. Sherstneva[a], Svetlana P. Mironova[b], Sergey A. Dneprov[b] and Yuriy P. Grabozdin[c]

[a]Samara State University of Economics, Samara, RUSSIA; [b]Russian State Vocational Pedagogical University, Ekaterinburg, RUSSIA; [c]Samara State University of Social Sciences and Education, Samara, RUSSIA

ABSTRACT

The relevance of this paper lies in the fact that football business has grown significantly in the past 20 years and football clubs have become large companies, which in an effort to be profitable and successful on the field need to improve the efficiency of their business. The aim of this article is to measure economic efficiency of 48 big European football clubs and assess the relationship between efficiency and different financial and sportive indicators (variables). To measure efficiency, we used both widely used Data Envelopment Analysis (DEA) method and its extensions: DEA Super-efficiency and DEA Cross-efficiency models. The results showed that these methods can successively be applied to football clubs' efficiency measurement and the analysis of the them can help to explain why some clubs are efficient or inefficient and which factors affects the efficiency. This paper will be interesting football clubs' managers, football analytics, economists and other people interested in football business because we combine in it the most interesting ideas and methods about football clubs' efficiency measurement.

KEYWORDS
Efficiency, football clubs, economic efficiency, data envelopment analysis (DEA), spearman's rank correlation coefficient

ARTICLE HISTORY
Received 14 May 2016
Revised 23 June 2016
Accepted 10 July 2016

Introduction

Football is the most popular sport in the world. In the past two decades, football clubs have become more than just sport organizations – they have

CORRESPONDENCE Aleksey V. Pyatunin ✉ brioso1983@gmail.com

become large commercial companies with revenues of hundreds of millions euro. According to Deloitte Football Money League report, top 30 European football clubs generate revenues equal to □6,6b (Deloitte, 2016).

Unlike most other studies, in this paper we decided to measure efficiency of football clubs in 2014 not from one country, but efficiency of the richest and strongest football clubs across Europe in 2012-2014. This choice can be explained by the fact that these clubs draw maximum media and football fans attention, these clubs together control the bigger part of revenues in European football industry, and they are the most successful ones on the field. So, it is very interesting to understand how efficiently such clubs spend their resources to achieve sportive and financial goals (these clubs really have something to spend).

In scientific literature there are two main approaches to study efficiency of professional football clubs: financial efficiency measurement and sports efficiency measurement (Kulikova & Goshunova, 2014). Financial efficiency refers to the ability of a football club to make profit, sports efficiency – to be successful on the field.

In our paper we consider both types of efficiency. We think that if a researcher wants to get the all-round understanding of a football club's efficiency, he must consider both main areas of activity of any football club: finance and sportive performance.

Because of the fact that we needed enough football clubs for measurement (30-50 football clubs), we decided to apply 4 criteria for selecting them. The first one is "Staff costs" (staff costs refer to wages of football players, technical staff, medical staff, management and administrative staff) which must be at average (in 2012-2014) over □30m. The second criterion is "Market value of a squad" (calculated by summing up market values of each player in a club**)** which must be at average (in seasons 2012 -2014) over □50m. The third one is participating in the strongest domestic divisions in 2012-2014. The fourth criterion is availability of data (all of the variables for a football club which used in DEA must be publicly available). According to these four criteria, we selected 48 football clubs from eight countries.

All the methods used to measure efficiency of football club can be divided into two large groups: Parametric methods and Non-parametric methods. Parametric methods are the methods, which use tools of deterministic correlation and regression analysis. They identify type of relationship between the variables and the functional dependence (Kulikova & Goshunova, 2014).

Non-parametric methods are focused primarily on the overall assessment of the efficiency, which is based on the analysis of a set of inputs and outputs which characterize the activity of the object under review (Kulikova & Goshunova, 2014).

The main method used in our paper is the most popular non-parametric method of clubs' efficiency measurement – Data Envelopment Analysis (DEA), which have some advantages over parametric methods. Also we used the Super-Efficiency as a ranking methodology introduced by P. Andersen & N. Petersen (1993) to differentiate the performance of extreme-efficient DMUs ((Decision Making Units) with the efficiency scores more than 100%.

Also, for comparison, we calculated efficiency using one of the extensions of DEA - DEA Cross Efficiency method. It provides an ordering among DMUs (Decision Making Units), and it eliminates unrealistic weight schemes without requiring the elicitation of weight restrictions from application area experts (Andersen, Hollingsworth & Inman, 2002). In the literature DEA Cross Efficiency method has not been used before.

The second stage of our study was to assess the strength of the relationship between the football clubs' efficiency and their variables. The purpose was to find out which variables correlates with the efficiency results best. Strong positive correlation means that such a variable is important for a club aiming to be efficient. To assess the relationship, we calculated Spearman's rank correlation coefficient with the use of Gretl software.

Relevance and uniqueness of our paper consist of the following factors:

— we analyze football clubs not from one country, but the richest and most influential football clubs from eight countries;

— we used not only DEA method (and Super-Efficiency method), but also its extension - DEA Cross Efficiency method and compared the results to find out which one is more reliable and logical;

— we consider both types od efficiency: financial and sportive;

— we used the combination of inputs and outputs that never used before.

Materials and Methods

Data envelopment Analysis

Data envelopment analysis (DEA) approach involves the use of linear programming methods to construct a non-parametric frontier (piece-wise surface) over the data. Efficiency measures are then calculated relative to this surface.

This piece-wise-linear convex hull approach was proposed by M. Farrell (1957) and was considered by only a few authors in the two decades following Farrell's research. DEA did not receive much attention until the paper by A. Charnes, W. Cooper & E. Rhodes (1978), in which the term data envelopment analysis (DEA) was first used. Since then a large number of papers have appeared, which have extended and applied the DEA methodology (Coelly et al., 2005; Lukinova, Smarchkova& Pisarenko (2014).

A. Charnes, W. Cooper & E. Rhodes (1978) proposed a model that was input-oriented and assumed constant returns to scale (CRS). After that paper, R. Banker, A. Charnes & W. Cooper (1984) and R. Faere, S. Grosskopf & J. Logan (1983) considered alternative sets of assumptions, in which variable returns to scale (VRS) models was proposed.

First, we describe DEA using the input-oriented CRS model because this model was the first to be widely applied.

T. Coelli, D. Prosada Rao, C. O'Donnel & G. Battese (2005) illustrated this model assuming there are data on N inputs and M outputs for each of I firms. For i-th firm these are represented by the column vectors xi (inputs) and qi (outputs) respectively. The N*I input matrix, X, and the M*I output matrix, Q, represent the data for all I firms.

For each firm, we need to obtain a measure of the ratio of all outputs over all inputs, such as u'qi / v'xi, where u is an M*1 vector of output weights and v is a N*1 vector of input weights. The optimal weights are obtained by solving the mathematical programming problem:

$Max_{u,v}\ (u'q_i/v'x_i)$,

subject to $u'q_j/v'x_j <= 1$, j=1,2,3…,I,

u, v >= 0

This involves finding values for u, v, such that the efficiency measure for the i-th firm is maximized, subject to the constraints that all efficiency measures must be less than or equal one. One problem with this particular ratio formulation is that it has an infinite number of solutions. To avoid this, one can impose the constraint v'xi = 1, which provides:

$Max_{u,v}\ (\mu'qi)$,

subject to $\nu'xi = 1$

$u'qj - \nu'xj <= 0$, j=1,2,3…,I,

u, ν>= 0,

where the change of notation from u and v to u and ν is used to stress that this is a different linear programming problem (Coelly et al., 2005).

Using the duality in linear programming, we can derive an equivalent envelopment form of this problem:

$min_{\theta,\lambda}\theta$,

subject to $-qi + Q\lambda >= 0$,

$\theta x_i - X\lambda >= 0$,

$\lambda >= 0$,

where θ is a scalar and λ is a I*1 vector of constraints. This envelopment form involves fewer constraints than the multiplier (N+M < I+1), and hence is generally the preferred from to solve. The value of obtained is the efficiency score for the i-th firm. It satisfies: θ<= , with a value 1 indicating a point on the frontier and hence technically efficient firm, according to M. Farrell (1957) definition (Coelly et al., 2005).

There are some difficulties in efficiency measurement because of the form of the non-parametric frontier in DEA. The problem arises because of the sections of the piece-wise linear frontier which run parallel to the axes (see Figure 16). In Figure 1 we can see, that there are two efficient firms C and D and two inefficient firms A and B. According to Farrell (1957), technical efficiency of firms A and B is 0A'/0A and 0B'/0B, respectively. However, it is questionable as to whether the point A' is an efficient point since one could reduce the amount of input x2 used (by the amount CA') and still produce the same output. This is known as input slack.

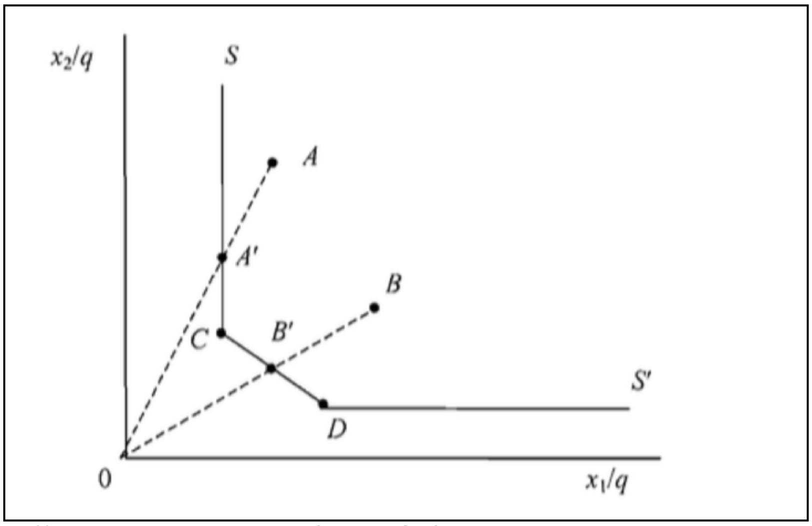

Figure 1. Efficiency measurement and input slacks

That's why any non-zero input or output slacks should be reported to provide an accurate technical efficiency of a firm in DEA. T. Koopmans (1951) defines technical efficiency more strictly stating, that a firm is only technically efficient if it operates on the frontier and furthermore that all associated slacks are zero.

For the i-th firm, the output slacks are equal to zero if $Q\lambda - qi = 0$ and input slacks are equal to zero if $\theta xi - X\lambda = 0$.

The CRS assumption is appropriate when all the firms are operating at an optimal scale. Some authors, such as R. Faere, S. Grosskopf & J. Logan (1983) and R. Banker, A. Charnes & W. Cooper (1984) proposed adjusting the CRS DEA model to account for variable returns to scale (VRS) situations. The use of the VRS specifications permits the calculation of TE devoid of the situation when not all firms are operating at the optimal scale (Coelly et al., 2005).

The CRS linear programming problem can be easily modified to account for VRS by adding the convexity constraint $I1'\lambda = 1$:

$\min_{\theta,\lambda}\theta$,

subject to $-q_i + Q\lambda >= 0$,

$\theta x_i - X\lambda >= 0$,

$I1'\lambda = 1$

$\lambda >= 0$,

where I1 is an I*1 vector of ones (Coelly et al., 2005).

The advantages of DEA are that:

- it can be used with multiple inputs and outputs simultaneously;

- it is capable of being used with any input-output measurements;

- it only requires information on output and input quantities (not prices) to calculate technical efficiency;

- it allows technical efficiency to be decomposed into scale effects;

The limitations of DEA are that:

- it produces results that are particularly sensitive to measurement error because it is deterministic technique rather than a statistical technique: if one DMU's inputs are understated or its outputs overstated, then that DMU can become an outlier that significantly affects the shape of the frontier (Karaduman, 2006);

- it only measures efficiency relative to best practice within the observed DMUs;

- DEA scores are sensitive to input and output specification and the size of the sample.

Super-efficiency DEA model

Since the early 1980s, DEA has been widely used for measuring the efficiency of independent homogenous units which use the same inputs to produce the same outputs. However, a serious inconvenience in the utilisation of DEA is the possibility of having units tied with efficiency equal to 100 percent. That is, units at the frontier of relative efficiency (Yawe, 2010). According to the DMUs' efficiency scores, DEA classifies the DMUs into two diverse efficient and inefficient groups. Unlike the inefficient DMUs, the efficient ones cannot be ranked based on their efficiencies because of having the same efficiency score of unity. However, it is clear that the efficient DMUs don't have the same performance in actual practice. The question is how to rank the efficient DMUs.

P. Andersen & N. Petersen (1993) introduced the super-efficiency as a ranking methodology to differentiate the performance of extreme-efficient DMUs.

The super-efficiency ranking enables one to distinguish between the efficient observations. For example, the super-efficiency measure examines the maximal radial change in inputs and /or outputs for a DMU to remain efficient, i.e. hoe much can the inputs be increased (or the outputs decreased) while not become inefficient. Super-efficiency measures can be calculated for both inefficient and efficient DMUs. In the case of inefficient DMUs the values of the efficiency measure do not change, while efficient DMUs may obtain values > 1 (Yawe, 2010).

P. Andersen & N. Petersen (1993) considered the DEA score for the inefficient unit as its rank scale. In order to rank the efficient DMUs they allow the efficient units to receive an efficiency score greater than 100 percent by dropping the constraint that bounds the score of the evaluated unit (Cooper, Seiford & Tone, 2000). For input-oriented DEA model with the assumption of VRS technology:

Min $(\theta, \lambda, s^+, s^-)$ $\quad z_0 = \theta_0 - \varepsilon s^+ - \varepsilon s^-$

subject to $\quad Y\lambda - s^+ = Y_0$

$\theta_0 X_0 - X\lambda - s^- = 0$

$\lambda_0 = 0$ and

$\lambda, s^+, s^- >= 0$

The efficiency score θ_0 is transformed into the so-called slack-augmented score z_0 by adding output slacks s^+ and input slacks s^- multiplied by ε - the non-Archimedean infinitesimal.

A standard DEA specification results when a constraint is ignored with the hospitals in the efficient set get a score that exceeds unity. This determines the factor by which the inputs of an efficient DMU can radially be expanded such that the DMU under consideration just stays efficient (Yawe, 2010).

To illustrate, Figure 2 shows four DMUs producing a single output and using two inputs $x_1 = x_2$. Points A, B, C are efficient DMUs (on the efficient frontier), D is inefficient one. Consider unit B. If it were excluded from the frontier, a new frontier would be created comprising only units A and C. The super-efficient score for unit B is obtainable by calculating its distance to the new frontier whereby this “additional” efficiency the increment that is permissible in its inputs before it would become inefficient. The consequence of this modification is to allow the scores for efficient units to exceed unity (Yawe, 2010).

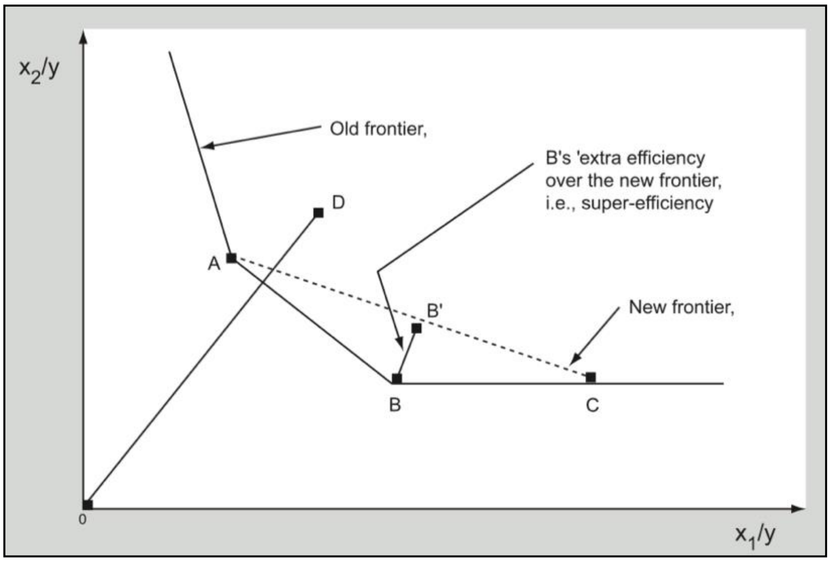

Figure 2. Super-efficiency model

Cross-efficiency DEA model

While DEA has been proven an effective approach for measuring efficiency, its flexibility in weighting multiple inputs and outputs and its nature of self-evaluation have been criticized. The cross efficiency method was developed as a DEA extension to rank DMUs, with the main idea being to use DEA to do peer evaluation, rather than to have it operate in a pure self-evaluation mode (Cook & Zhu, 2015).

To illustrate cross-efficiency approach, suppose we have a set of n DMUs and each DMU_j have s different outputs and m different inputs. We denote the i-th input and r-th output of DMU_j (j = 1,2, . . . , n) as x_{ij}(i = 1,...,m) and y_{rj}(r = 1,...,s), respectively. Cross efficiency is generally presented as a two-phase process. Specifically, phase one is the self-evaluation phase where DEA scores are calculated using the constant returns-to-scale (CRS) DEA model. In the second phase, the multipliers arising from phase one are applied to all peer

DMUs to arrive at the so-called cross evaluation score for each of those DMUs (Cook & Zhu, 2015).

Phase 1: Suppose DMU_d is under evaluation by the CRS model (Charnes, Cooper & Rhodes,1978). Then that DMU's (self-evaluation) efficiency score is determined by the following DEA model:

$$\text{Max} \quad E_{dd} = \Sigma^{s}_{r=1}(u_{rd} * y_{rd}) \,/\, \Sigma^{m}_{i=1}(v_{id} * x_{id})$$

$$\text{subject to} \quad E_{dj} = \Sigma^{s}_{r=1}(u_{rd} * y_{rj}) \,/\, \Sigma^{m}_{i=1}(v_{id} * x_{ij}) <= 1, \;\; j = 1,2, \ldots, n$$

$$u_{r,d} >= 0, \; r = 1,2, \ldots, s.$$

$$v_{i,d} >= 0, \; i = 1,2, \ldots, m.$$

where v_{id} and u_{rd} represent i-th input and r-th output weights for DMU_d(Cook & Zhu, 2015).

Phase2: The cross efficiency of DMU_j, using the weights that DMU_d has chosen in model above, is given by

$$E_{dj} = \Sigma^{s}_{r=1}(u^{*}_{rd} * y_{rj}) \,/\, \Sigma^{m}_{i=1}(v_{id} * x_{ij}), \; d, j = 1,2, \ldots, n$$

where (*) denotes optimal values in model. For DMUj (j = 1, 2, · · ·, n), an average of all E_{dj}(d = 1,2,..,n),

E_j(average) = $1/n * \Sigma^{n}_{d=1}(E_{d,j})$, is referred to as the cross efficiency for DMU_j.

There are six DMUs. E_{dj} is the (cross) efficiency of DMU_j based upon a set of DEA weights calculated for DMU_d. This set of DMU weights gives the best efficiency score for DMU_d under evaluation by a DEA model, and E_{dd} (in the leading diagonal) is the DEA efficiency for DMU_k. The cross efficiency for a given DMU_j is defined as the arithmetic average down column j, given by E_j(average).

Data

To select variables for efficiency measurement, we looked for the data which must be publicly available, both sportive and financial and related to football clubs. As inputs we selected five variables such as:

— Staff costs (SC) (□m). This variable is used by many authors in their studies because it reflects how a club is capable to attract good players, managers and technical stuff for achieving its aims for a football season. It is obvious that the more you spend, the more you want to achieve, and amount of spending on staff (which is the main result maker) affects the outcome very much. Because of the fact that the wage cost figure and notes disclosed within the financial statements of professional football clubs generally does not allow any further breakdown and analysis (football players, technical staff, medical staff, management and administrative staff wages), there is only publicly data available relating to total staff costs. So, in our paper we assume that Staff costs are total staff costs. We collected Staff costs data from the database of Internet portal "Football Benchmark" (https://www.footballbenchmark.com) which is maintained by KPMG – a professional service company, being one of the Big Four auditors, along with Deloitte, EY and PwC. They have large amount of financial and sportive data which is taken from publicly available resources. Financial data are acquired from official Financial statements of professional football clubs from the relevant public sources in each country or from a club's official website. So, this data is absolutely trustworthy.

— Market value of a squad (MV) (£m). This variable is similar to Staff costs, but reflects not amount of money spent for staff, but the pure strength of a

team which is calculated by summing up market value of each player in a club. Players is one of the main assets of a club which also affects the outcome much. This data was acquired from the site Transfermarkt (http://www.transfermarkt.co.uk/) which specializes on football transfers news.

— Country strength coefficient (CST). As we selected football clubs from different National leagues, we needed to find the way to put them in equal starting conditions. It is obvious that, for example, for Manchester, which plays in English Premier League, to finish at the first place and qualify for UEFA Champions League is much harder than, for example, for Fenerbahce which plays in Turkish League, because the sportive strength of the football clubs from England is much higher than from Turkey. Considering that this coefficient must be logical, and not too artificial, we decided to use such method: we found the data of market value of all the football clubs for 2012-2014 for each country on Transfermarkt site, then we summed up all the market values for each league for years 2012-2014, in other words we calculated the strength of a league in terms of market value of clubs in it. It is obvious that the more value of input, the more the better. For example, a football club is in a preferred position, if it spends more on wages and has a stronger squad. It has the right to expect more outcome than a club which spends less money and has a weaker squad. That is why, football clubs from the weakest league have the highest Country strength coefficient. In this case it reflects the fact that it is easier to achieve success in that league. In all three seasons 2012-2014 the Dutch football league was the weakest one and the Dutch football clubs have Country strength coefficient equal to 1. Coefficient for other countries is calculated by dividing market value of the Dutch league by the market value of other league in the corresponding season. The strongest league – English Premier League has the lowest Country strength coefficient.

— Participating in the European Cups (EU). This variable is used to separate football clubs, which participate only in domestic tournaments from the clubs, which participate also in UEFA Champions League or UEFA Europe League and have better opportunities to earn more revenues. The the data was found on the official UEFA site (www.uefa.com/).

— Participating in UEFA Champions League (CL). This variable is used to separate clubs which participate in UEFA Champions League and UEFA Europa League, because the starting conditions for the clubs which participate in UEFA Champions League are more preferable to the clubs which in UEFA Europa League. There is no point in expecting from a club participating in UEFA Europa League to get as much money as it would get if it reached the same stage in UEFA Champions League. The the data was found on the official UEFA site (www.uefa.com/).

— As outputs we selected five variables such as:

— Revenues (REV). This variable is widely used in the studies as output because it is the main indicator of financial success of a club at the end of a football season and of course it affects financial efficiency much. Due to the fact that this variable intended for Domestic efficiency I found the data for Total revenues and deducted from them Prize money (for promoting to the next stage of a tournament) and Market pool money (distributed according to the proportional value of each TV market represented by the clubs taking part in tournament) which football clubs received for successful performance in UEFA

Champions League and UEFA Europa League. The data for total revenues I found on Internet portal Football Benchmark and the data for prize money and market pool money I found in the official reports published by UEFA yearly.

— Points per a game in a National League (PGD). This variable is also widely used as output indicating sportive success of a club in a domestic championship. The points per game a club receives, the more chances to win the championship, qualify for UEFA European tournaments, and attract more fans. This variable is calculated by dividing the points points obtained by a football club during the whole season by number of games played by a club. I found the data for points per game on website Soccerway (http://int.soccerway.com/) which publishes football results and other football statistical data for every country in the world.

— Qualification for the European Cups for the next season (ECQ). This variable affects domestic efficiency very much because participating in the European Cups allows a football club to become more popular among football fans, get prize money for good sportive performance in a tournament and improve its reputation in European football. If a club qualified for a European Cup for the next year, then the variable is equal to 1, if not – 0. I found the data on the official UEFA site (www.uefa.com/).

— Qualification for UEFA Champions League for the next season (CLQ). This variable has even more impact on efficiency than the previous one, because UEFA Champions League is the strongest and most prestigious European tournament for football clubs. Clubs which participate in that tournament get many times more money as if they participated in UEFA Europa League. That is why this variable reflects high expectations for the next football season for a football club which qualified in that tournament. If a club qualified for UEFA Champions League for the next year, then the variable is equal to 1, if not – 0. The data was found on the official UEFA site (www.uefa.com/).

— Prize money for sportive performance in a European Cup (PM) (£m). This variable reflects financial success of a football club in a European Cup. A football club receives Prize money for playing and further promoting to the nest stage of a tournament. So, amount of Prize money is solely dependent on sportive performance of a football club. The further a club goes in a tournament; the more money it gets. That is why this variable is a very important indicator of efficiency of a football club in the European Cups. The data was obtained from the official reports published by UEFA yearly.

All the inputs and outputs for all 48 clubs are shown in Table 1.

Table 1. Football clubs' inputs and outputs

	SC	MV	CST	EU	CL	REV	PGD	ECQ	CLQ	PM
Fenerbahce	69	117,99	0,562	1	1	108	2,18	1	1	2,10
Galatasaray	97	133,67	0,562	1	1	74	1,91	1	1	14,60
Besiktas	49	88,50	0,562	1	0	49	1,82	1	1	0,00
Ajax	48	79,46	1,000	1	1	83	2,09	1	1	11,80
PSV	29	71,06	1,000	1	1	58	1,74	1	0	3,90
Benfica	63	180,34	0,627	1	1	85	2,47	1	1	16,60
Porto	49	135,60	0,627	1	1	58	2,03	1	1	11,60

Real Madrid	269	454,95	0,241	1	1	490	2,29	1	1	36,90
Barcelona	248	465,26	0,241	1	1	443	2,29	1	1	20,50
Atletico Madrid	113	196,58	0,241	1	1	120	2,37	1	1	32,90
Valencia	58	135,49	0,241	1	0	85	1,29	0	0	4,60
Sevilla	59	110,33	0,241	1	0	56	1,66	1	0	9,60
Manchester United	263	383,81	0,159	1	1	474	1,68	0	0	21,00
Chelsea	230	437,23	0,159	1	1	346	2,16	1	1	24,90
Arsenal	199	249,53	0,159	1	1	331	2,08	1	1	18,20
Manchester City	246	359,25	0,159	1	1	382	2,26	1	1	17,10
Liverpool	172	204,38	0,159	0	0	306	2,21	1	1	0,00
Tottenham Hotspur	126	222,00	0,159	1	0	210	1,82	1	0	3,45
Everton	83	163,13	0,159	0	0	144	1,89	1	0	0,00
Newcastle United	93	141,64	0,159	0	0	155	1,29	0	0	0,00
Aston Villa	83	87,23	0,159	0	0	133	1,00	0	0	0,00
Fulham	82	111,26	0,159	0	0	110	0,84	0	0	0,00
Sunderland	83	113,44	0,159	0	0	125	1,00	0	0	0,00
Stoke City	73	94,50	0,159	0	0	118	1,32	0	0	0,00
West Bromwich	79	68,96	0,159	0	0	104	0,95	0	0	0,00
Swansey City	76	88,93	0,159	1	0	114	1,11	0	0	2,30
Bayern Munich	215	362,98	0,279	1	1	443	2,65	1	1	25,90
Schalke 04	114	140,21	0,279	1	1	190	1,88	1	1	17,70
Borussia D.	108	213,86	0,279	1	1	227	2,09	1	1	20,00
Hamburger SV	59	83,78	0,279	0	0	125	0,79	0	0	0,00
SV Werder Bremen	48	55,84	0,279	0	0	96	1,15	0	0	0,00
Hannover 96	36	62,66	0,279	0	0	77	1,24	0	0	0,00
TSG 1899 Hoffenheim	49	57,81	0,279	0	0	65	1,29	0	0	0,00
Paris Saint-Germain	244	278,18	0,386	1	1	407	2,34	1	1	20,50
Olympique de Marseille	80	110,74	0,386	1	1	97	1,58	0	0	8,60
Olympique Lyonnais	74	84,19	0,386	1	1	92	1,61	1	0	5,70
LOSC Lille	59	56,40	0,386	0	0	69	1,87	1	1	0,00
FC Girondins de Bordeux	48	47,51	0,386	1	0	53	1,39	0	0	1,50
Montpellier HSC	34	42,60	0,386	0	0	38	1,11	0	0	0,00
AC Milan	155	218,51	0,233	1	1	174	1,50	0	0	17,70
FC Inter Milan	117	204,60	0,233	0	0	155	1,58	1	0	0,00
Juventus FC	184	301,54	0,233	1	1	234	2,68	1	1	13,10
SSC Napoli	89	174,36	0,233	1	1	126	2,05	1	1	13,15
AS Roma	107	160,91	0,233	0	0	128	2,24	1	1	0,00
SS Lazio	52	120,99	0,233	1	0	75	1,47	0	0	2,60
ACF Fiorentina	75	166,95	0,233	1	0	78	1,71	1	0	3,00
Udinese Calcio	30	90,11	0,233	1	0	50	1,16	0	0	0,09
Genoa CFC	47	78,21	0,233	0	0	58	1,16	0	0	0,00

Results

The efficiency and super-efficiency measurement was conducted by using EMS (Efficiency Measurement System) Data Envelopment Analysis Software. This software can be downloaded for free (http://www.holger-scheel.de/ems/) and very popular among researchers. The advantage of EMS is that it can measure not only normal efficiency, but also super-efficiency for clubs which have

efficiency more than 1. The correlation between the variables and efficiency was conducted by using Gretl software - open-source software for econometric analysis (http://gretl.sourceforge.net/index.html).

We used the input-oriented model of DEA for efficiency measurement because this model tries to find out how to improve the input characteristics of the DMU concerned for it to become efficient, in other words, the model tries to minimize inputs without changing outputs. It can be applied to football clubs' efficiency, because a football club can not control the outputs which it wants to achieve, even it has made some forecasts and plans for the future before the start of a season; and many outputs which I used in my thesis can not be increased constantly, growth for them is limited. For example, a football club can not have points per a game more than 3 (because a win is awarded 3 points) or to win Prize money for participating in UEFA Champions League more than it is established by the rules of the tournament, or Qualification in a European Cup for the next season would be equal to 1 for a club which spent for the staff €300m or €30m. In contrast to outputs, most inputs can be controlled: a football club can reduce spending on its staff or sell some players. That is why more logical in this case to find the ways for increasing efficiency by reducing the amount of inputs while achieving the same outputs. Input-oriented model of DEA can be more useful in this case.

We used both Constant returns to scale (CRS) and Variable returns to scale (VRS) models to find out scale effect and calculate scale efficiency.

The results for football clubs' efficiency in 2014 are shown in Table 2.

Table 2. Football clubs' efficiency results in 2014

Football clubs	Cross Efficiency		Super Efficiency			Normal Efficiency		
	CRS	Rank	CRS	Rank	VRS	CRS	VRS	Scale
Liverpool	0,824	1	2,616	3	big	1,000	1,000	1,000
LOSC Lille	0,780	2	2,853	2	2,853	1,000	1,000	1,000
Atletico Madrid	0,768	3	1,749	4	2,108	1,000	1,000	1,000
Real Madrid	0,739	4	1,331	8	big	1,000	1,000	1,000
Bayern Munich	0,724	5	1,092	24	big	1,000	1,000	1,000
Borussia D.	0,713	6	1,190	16	1,190	1,000	1,000	1,000
Everton	0,708	7	1,401	7	1,401	1,000	1,000	1,000
Sevilla	0,698	8	3,157	1	big	1,000	1,000	1,000
Arsenal	0,697	9	1,194	15	1,194	1,000	1,000	1,000
Schalke 04	0,690	10	1,232	11	1,232	1,000	1,000	1,000
AS Roma	0,658	11	1,198	14	big	1,000	1,000	1,000
Chelsea	0,641	12	1,186	17	1,186	1,000	1,000	1,000
Manchester City	0,630	13	1,089	25	1,197	1,000	1,000	1,000
Paris Saint-Germain	0,624	14	1,060	27	1,159	1,000	1,000	1,000
Barcelona	0,613	15	0,958	36	0,962	0,958	0,962	0,996
Tottenham Hotspur	0,611	16	1,186	18	1,186	1,000	1,000	1,000
SSC Napoli	0,608	17	1,139	20	1,139	1,000	1,000	1,000
Manchester United	0,585	18	1,243	10	1,443	1,000	1,000	1,000
Benfica	0,560	19	1,109	22	2,154	1,000	1,000	1,000
SV Werder Bremen	0,556	20	1,212	12	1,232	1,000	1,000	1,000
Hannover 96	0,554	21	1,272	9	1,274	1,000	1,000	1,000
Ajax	0,543	22	1,480	6	1,486	1,000	1,000	1,000

Juventus FC	0,539	23	0,952	38	big	0,952	1,000	0,952
Stoke City	0,530	24	0,986	31	1,077	0,986	1,000	0,986
Aston Villa	0,513	25	0,982	32	1,053	0,982	1,000	0,982
Porto	0,512	26	1,139	19	1,139	1,000	1,000	1,000
FC Inter Milan	0,506	27	0,774	46	0,774	0,774	0,774	1,000
Besiktas	0,504	28	1,204	13	1,204	1,000	1,000	1,000
Newcastle United	0,501	29	0,915	39	1,000	0,915	1,000	0,915
Hamburger SV	0,488	30	1,074	26	1,094	1,000	1,000	1,000
ACF Fiorentina	0,482	31	0,904	41	0,904	0,904	0,904	1,000
Galatasaray	0,474	32	0,841	43	0,841	0,841	0,841	1,000
West Bromwich	0,467	33	0,958	37	1,165	0,958	1,000	0,958
Swansey City	0,453	34	1,031	28	1,106	1,000	1,000	1,000
TSG 1899 Hoffenheim	0,452	35	0,910	40	1,026	0,910	1,000	0,910
Sunderland	0,451	36	0,816	44	1,000	0,816	1,000	0,816
Fenerbahce	0,448	37	0,999	29	1,057	0,999	1,000	0,999
Valencia	0,422	38	0,977	33	0,999	0,977	0,999	0,977
AC Milan	0,421	39	0,730	47	0,809	0,730	0,809	0,902
Olympique Lyonnais	0,417	40	0,966	34	0,966	0,966	0,966	1,000
SS Lazio	0,401	41	0,962	35	0,966	0,962	0,966	0,996
Genoa CFC	0,399	42	0,858	42	1,026	0,858	1,000	0,858
Fulham	0,397	43	0,723	48	1,000	0,723	1,000	0,723
Montpellier HSC	0,376	44	0,997	30	1,342	0,997	1,000	0,997
PSV	0,374	45	1,655	5	1,655	1,000	1,000	1,000
FC Girondins de Bordeux	0,365	46	1,102	23	1,214	1,000	1,000	1,000
Olympique de Marseille	0,340	47	0,804	45	0,819	0,804	0,819	0,981
Udinese Calcio	0,324	48	1,124	21	1,206	1,000	1,000	1,000

According to the Cross-efficiency results Liverpool (2nd in English Premier League (the strongest championship in Europe), did not participate in the European Cups), LOSC Lille (3rd in Ligue 1 with relatively weak inputs, did not participate in the European Cups), Atletico Madrid (the winner of La Liga, the finalist of UEFA Champions League). The worst performers are Udinese Calcio (13th in Serie A, eliminated in the preliminary stage of UEFA Europa League), Olympique de Marseille (6th in Ligue 1 with the relatively strong inputs, 4th in the group stage of UEFA Champions League loosing all the matches), FC Girondins de Bordeux (only 7th in Ligue 1, 4th in the group stage of URFA Europa League). The Cross-efficiency results look very logical and they are more trustworthy than Super-efficiency results. The Spearman's rank correlation coefficient between them is good - 63,8%, but there is relatively a large number of clubs with the big difference in the ranks for the Cross- and Super-efficiency, such as Bayern Munich (Cross-efficiency rank -5th, Super-efficiency rank – 24th), Barcelona (Cross-efficiency rank -15th, Super-efficiency rank – 36th), PSV (Cross-efficiency rank -45th, Super-efficiency rank – 5th) and Ajax (Cross-efficiency rank -22nd, Super-efficiency rank – 6th) and others. Super-efficiency results of those clubs are very strange – Barcelona and Bayern Munich performed very good in the national championships and in UEFA Champions League, earned much revenues, but are only 36th and 24th respectively, while PSV did not even qualify for UEFA Champions League having very strong squad for the Dutch Championship and performed bad in the European Cups.

If we look at the weights for the football clubs' variables shown in *Table 3*, we can notice that some variables (both inputs and outputs) of each football club have weight equal to 0, in other words, when efficiency is calculated not all the inputs and outputs are taken into account. While calculating the software selects the variables which can achieve the best possible efficiency and avoids the others. This can lead to unrealistic weight schemes when some weights are equal to 0 or too many football clubs have 100%-efficiency or more.

Table 3. The weights for the football clubs' variables

Football clubs	SC	MV	CST	EU	CL	TC	PGD	EC	CL	PM
Fenerbahce	0,011	0,000	0,330	0,000	0,000	0,003	0,209	0,049	0,133	0,000
Galatasaray	0,000	0,006	0,261	0,000	0,000	0,000	0,000	0,181	0,280	0,026
Besiktas	0,020	0,000	0,000	0,000	1,170	0,000	0,000	0,475	0,729	0,046
Ajax	0,011	0,006	0,000	0,000	0,000	0,004	0,216	0,000	0,287	0,034
PSV	0,034	0,000	0,000	0,000	0,000	0,000	0,000	1,655	0,000	0,000
Benfica	0,010	0,000	0,086	0,226	0,116	0,000	0,298	0,000	0,000	0,023
Porto	0,015	0,000	0,420	0,000	0,000	0,000	0,000	0,240	0,733	0,014
Real Madrid	0,000	0,000	1,136	0,198	0,529	0,001	0,000	0,000	0,000	0,028
Barcelona	0,003	0,000	1,357	0,000	0,000	0,002	0,000	0,014	0,075	0,001
Atletico Madrid	0,003	0,002	1,188	0,000	0,000	0,000	0,000	0,000	0,000	0,053
Valencia	0,015	0,000	0,629	0,000	2,362	0,008	0,083	0,000	0,029	0,046
Sevilla	0,000	0,008	0,561	0,000	7,677	0,000	0,000	0,659	0,000	0,260
Manchester United	0,000	0,000	5,331	0,066	0,088	0,003	0,000	0,000	0,000	0,000
Chelsea	0,000	0,000	6,305	0,000	0,000	0,000	0,158	0,085	0,115	0,026
Arsenal	0,000	0,002	2,699	0,000	0,000	0,001	0,000	0,227	0,227	0,014
Manchester City	0,000	0,000	5,699	0,014	0,022	0,002	0,000	0,104	0,177	0,000
Liverpool	0,000	0,000	6,305	0,409	2,301	0,006	0,000	0,010	0,631	0,006
Tottenham Hotspur	0,000	0,000	6,305	0,000	1,885	0,000	0,000	1,000	0,000	0,054
Everton	0,005	0,000	3,949	0,592	0,689	0,000	0,000	1,401	0,000	0,014
Newcastle United	0,010	0,000	0,488	0,716	1,101	0,005	0,065	0,000	0,000	0,019
Aston Villa	0,000	0,011	0,389	0,523	1,292	0,007	0,000	0,000	0,000	0,032
Fulham	0,011	0,000	0,548	0,435	0,790	0,006	0,073	0,000	0,000	0,016
Sunderland	0,011	0,000	0,542	0,453	0,809	0,006	0,072	0,000	0,000	0,016
Stoke City	0,002	0,005	2,218	0,737	0,800	0,001	0,637	0,000	0,000	0,026
West Bromwich	0,000	0,012	1,221	0,329	0,669	0,006	0,400	0,000	0,000	0,028
Swansey City	0,000	0,011	0,382	0,000	2,774	0,007	0,000	0,000	0,000	0,088
Bayern Munich	0,004	0,000	0,264	0,044	0,006	0,002	0,000	0,000	0,000	0,001
Schalke 04	0,000	0,007	0,250	0,000	0,000	0,003	0,000	0,100	0,164	0,023
Borussia D.	0,008	0,000	0,303	0,000	0,000	0,003	0,000	0,075	0,189	0,012
Hamburger SV	0,014	0,001	0,393	0,668	1,434	0,009	0,000	0,000	0,000	0,025
SV Werder Bremen	0,003	0,016	0,000	0,744	1,393	0,011	0,161	0,000	0,000	0,047
Hannover 96	0,027	0,000	0,064	0,952	1,022	0,006	0,652	0,000	0,000	0,052
TSG 1899 Hoffenheim	0,007	0,004	1,459	1,569	1,811	0,004	0,508	0,000	0,000	0,044
Paris Saint-Germain	0,000	0,003	0,097	0,131	0,084	0,002	0,000	0,000	0,000	0,015
Olympique de Marseille	0,006	0,003	0,403	0,000	0,000	0,003	0,276	0,000	0,000	0,014

Olympique Lyonnais	0,005	0,006	0,438	0,000	0,000	0,002	0,000	0,654	0,000	0,027
LOSC Lille	0,000	0,018	0,000	1,412	1,373	0,000	0,000	1,743	1,110	0,075
FC Girondins de Bordeux	0,000	0,021	0,000	0,000	2,344	0,008	0,328	0,000	0,000	0,136
Montpellier HSC	0,025	0,003	0,000	0,856	1,141	0,000	0,898	0,000	0,000	0,071
AC Milan	0,000	0,003	0,487	0,120	0,043	0,002	0,000	0,000	0,000	0,021
FC Inter Milan	0,006	0,001	0,000	0,314	0,541	0,004	0,000	0,183	0,000	0,011
Juventus FC	0,001	0,000	3,201	0,000	0,000	0,000	0,330	0,000	0,018	0,004
SSC Napoli	0,006	0,000	1,818	0,000	0,000	0,001	0,000	0,258	0,788	0,002
AS Roma	0,005	0,000	1,953	0,323	0,687	0,000	0,388	0,000	0,330	0,013
SS Lazio	0,014	0,000	1,119	0,000	1,464	0,004	0,425	0,000	0,068	0,019
ACF Fiorentina	0,007	0,000	2,045	0,000	0,447	0,000	0,000	0,904	0,039	0,000
Udinese Calcio	0,028	0,000	0,699	0,000	1,278	0,000	0,967	0,000	0,000	0,022
Genoa CFC	0,013	0,000	1,493	1,017	0,806	0,000	0,739	0,000	0,000	0,037

For example, PSV's Country strength coefficient variable's weight is equal to 0, but this variable indicates how easy to get points in the championship and qualify for the European Cups. Given that the Dutch championship was the weakest in 2014, while measuring the efficiency good ratio of points/games was not offset by the weakness of the championship. All the clubs in 2014 have some weights equal to 0, but in different combinations. That is why some clubs have unrealistic weights and this situation leads to unrealistic efficiency results for them. If we look at the Cross-efficiency results, we can notice that there are no strange or illogical results for any football club, all the results correspond to the variables.

As mentioned above, one of the aims of our paper was to compare Cross-efficiency and Normal- (Super-) efficiency results and check whether the Cross-efficiency method is more logical by providing an ordering among football clubs by eliminating unrealistic weight schemes. Given that disadvantage of normal DEA and based on logical reasoning (by comparing the Cross- and Super-efficiency for all the football clubs), we conclude that the results for Cross-efficiency look more logical with taking into account all the variables given. DEA Cross-efficiency method really eliminates unrealistic weight schemes, which can occur if a researcher uses simple DEA method.

If we look at Table 2 we can see that the richest and strongest third part of 48 clubs (16 top clubs such as Real Madrid, Barcelona, Bayern and others) are more efficient than others. It can be explained by the fact that with the help of the strongest inputs they achieve high (expected) results more consistently: they finish almost always in top 4 of the national championships (with rare exceptions), participate in UEFA Champions League and their revenues continue to grow (also with rare exceptions). The most vulnerable part of their performance was only participation in the European Cups because unlike the national championships where all the points are taken into account for determining the winner, in the European Cups, there is a playoff system, which introduces an element of randomness and performance of football clubs much depends on the sportive form of the clubs at that particular moment. However, even if a top club does not perform well in the European Cups, its revenues will

not drop dramatically because, besides this source of revenues, there are many other sources of revenues for a top club, which will not be much affected by the poor performance in the European Cups. Of course, there are always exceptions like extremely inefficient FC Inter Milan or AC Milan, which even with very strong inputs did not perform well nor in Serie A, or in the European Cups.

Moreover, it is important to point out that some clubs, which strongly dominate in their national championships, like Real Madrid and Barcelona in Spain, Paris Saint-Germain in France, the strongest clubs from Portugal, Netherlands, and Turkey, even if they win the championships, they are not the most efficient clubs because of the excess of the inputs. Their inputs are stronger than enough to be very successful on the national level. However, the reason why these clubs continue this situation is mainly because they want to be successful on the European level where the competitors are much stronger. And if such a club is successful in the European Cups too, then its efficiency is very good (Real Madrid, Barcelona), otherwise their efficiency can decrease much (Fenerbahce, Besiktas, PSV, and Ajax).

The results of the second stage of the analysis of the football clubs in our paper, the relationship between the efficiency scores (Cross-efficiency scores) and the variables, are shown in Table 4.

Table 4. Correlation between the variables and the efficiency scores

Variable	Input/Output	Spearman's rank coeff.
Staff Costs	Input	0,527
Market value of a squad	Input	0,505
Country strength coefficient	Input	-0,227
Participation in the European Cups	Input	0,026
Participation in UEFA Champions League	Input	0,232
Revenues	Output	0,552
Points per a game in a national championship	Output	0,629
Qualification for the European Cups for next season	Output	0,621
Qualification for UEFA Champions League for next season	Output	0,619
Prize Money	Output	0,501

Based on the results above in Table 4, we can make some conclusions.

1. All the outputs have positive correlation with efficiency. The results are logical: the more prize money, revenues, points the clubs get, the more efficient they are. All the outputs have very similar correlation coefficients and it means that if a club wants to be efficient both sportively and financially, it can achieve that aim only performing good both in its own country and in Europe which will lead also to good amount of revenues.

2. The inputs are not so equally correlated as the outputs. The most correlated inputs with efficiency are Staff Costs and Market Value of a squad, they have good positive correlation. It means that if the clubs want to be successful not only on a domestic, but also on European level, it must have strong squads and spend much money on its players. Weak clubs can be efficient on a domestic level (with their weak inputs), even be efficient without qualifying

for the European Cups, but when we consider all possible tournaments and ways of earning revenues, not participating in the European Cups decreases efficiency of a football club. That is why stronger clubs are more efficient than the weak ones, of course with some exceptions (we can see it in Table 2).

3. Participation in UEFA Champions League input have quite weak positive correlation. It means that participation UEFA Champions League has positive effect on efficiency, but only the fact of participation in them does not mean that the club is efficient.

4. Participation in the European Cups input does not correlate with efficiency. It means that only fact of participation in the European Cups does not lead a football club to efficiency. To be efficient, a football club must perform well in any tournament.

5. Country strength coefficient input has weak negative correlation with efficiency. It means that the stronger championship a football club from (input has less value in this case), the more this club is efficient. It quite well corresponds to Staff Costs and Market Value of a squad correlations results because the strongest and richest clubs (which are more Total efficient than the weakest clubs) play in the strongest championships.

Discussions

Nowadays understanding of football economy is becoming more important. In the economic literature many researches are devoted to the analysis of the efficiency of professional football club as business unit. The variety of tools of economic analysis provides the assessment of the clubs' efficiency from different points of view (Kulikova & Goshunova, 2013).

In terms of objects of study, most researches analyzed English football clubs. The popularity of choosing English football clubs as objects of analysis is mainly because they were the first ones floated on the stock market and therefore, there is a lot of publicly available information about them. The Premier League is the most popular football league in the world, that many strong clubs and players play in. Also there are several researches of football clubs from Spain, mainly because football super clubs Real Madrid and Barcelona and some other strong clubs play in this country, and the information needed for analysis is also available. There are not so many researches from another particular country conducted, only 1-2 researches for each country: Germany, France, Brazil, Denmark, Iran, Japan, India, Turkey, Greece, Portugal, Norway, Netherlands. There are only a few researches about football clubs not from one, but from several countries.

In terms of methods of study, the researches used parametric or non-parametric methods (more often). Non-parametric methods were used by different authors such as A.S. Ribeiro & F. Lima (2012), C. Barros & J. Douvis (2009), F. González-Gómez (2010), C. Barros & P. Garcia-del-Barrio (2008), P. Dawson & S. Dobson (2002), B. Frick & R. Simmons (2007), I. Garcia-Sanchez (2007), I. Guzman & S. Morrow (2007), L. Kulikova & A. Goshunova (2013, 2014), D. Haas (2003), G. Halkos & N. Tzeremes (2011), M. Jardin (2009), M. Kern & B. Süssmuth (2003), J. Soleimani-Damaneh, M. Hamidi & N. Sajadi, L. (2011), García-Cebrián & M. Espitia-Escuer (2004, 2014, 2015a, 2015b), D. Zhao (2013).

In the literature, researchers consider the efficiency of football club from different points of view- according to the aims of football clubs. The are two main approaches are developed to study the efficiency of a football club in the scientific literature: evaluation of pure economic (or financial) efficiency and evaluation of pure sportive efficiency. Also, there are some researches, which combine evaluation both financial and sportive efficiencies.

Some of the variables used in our paper (like points per a game, revenues, staff costs) are widely used in other researches, but many of the variables used in our paper not used by others. There are no researches on football clubs' efficiency, which include measurement efficiency using DEA Super-efficiency or DEA Cross-efficiency. Also, there are many researches, which include measurement of correlation between two or more variables, but not between variables and efficiency scores.

In our paper we combined different interesting methods and ideas on football clubs' efficiency and it makes it unique and relevant.

Conclusion

Summing up the results, we can make some important conclusions.

The use of simple DEA method for the football clubs' measurement proved to be effective, but the known disadvantages of this method were also discovered. DEA Cross-efficiency method really improved the results of simple DEA method by eliminating unrealistic weights for the variables, the results are logical, reasonable. The efficiency results showed that richest clubs more efficient than the poor clubs, because they have access to all the tournaments and sources of revenues, which help them to be efficient in the future even if they don't perform good in one particular season.

Also, some clubs, which strongly dominate in their national championships, like Real Madrid and Barcelona in Spain, Paris Saint-Germain in France, the strongest clubs from Portugal, Netherlands, and Turkey, even if they win the championships, they are not the most efficient clubs because of the excess of the inputs. Their inputs are stronger than enough to be very successful on the national level. However, the reason why these clubs continue this situation is mainly because they want to be successful on the European level where the competitors are much stronger. And it is important for them to find the balance of remaining dominant in the national championships and being successful in Europe with the least possible inputs.

The results of the correlation analysis are also logical and showed that for being efficient, football clubs must succeed in all areas of activity: domestic, European competitions, finance. As for the inputs, the correlation results for Staff Costs and Market Value confirmed the conclusions that richest clubs are more efficient: the stronger these inputs, the more efficient football clubs.

Thus, we can make a conclusion that these methods proved to be useful and informative regarding football clubs' efficiency measurement. Our paper will be interesting for football clubs' managers, football analytics, economists and other people interested in football business.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Aleksey V. Pyatunin is Graduate Studentof Samara State Universiry of Economics, Samara, Russia.

Angelina B. Vishnyakova is Associate professor of Samara State Universiry of Economics, Samara, Russia.

Natalia L. Sherstneva is Associate professor of Samara State Universiry of Economics, Samara, Russia.

Svetlana P. Mironova is Associate professor of Russian State Vocational Pedagogical University, Ekaterinburg, Russia.

Sergey A. Dneprov is Professor of Russian State Vocational Pedagogical University, Ekaterinburg, Russia.

Yuriy P. Grabozdin is Senior Lecturer of. Samara State University of Social Sciences and Education, Samara, Russia.

References

Andersen, P. & Petersen, N. (1993). A Procedure for Ranking Efficient Units in Data Envelopment Analysis. *Management Science, 39(10),* 132-143.

Andersen, T., Hollingsworth, K. & Inman, L. (2002). The fixed weighting nature of a cross-evaluation model. *Journal of Productivity Analysis,1*, 249-255.

Banker, R., Charnes, A. & Cooper, W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science, 30,* 1078-1092.

Barros, C. & Douvis, J. (2009). Comparative analysis of football efficiency among two small European countries: Portugal and Greece. *International Journal of Sport Management and Marketing, 6,* 183-199.

Barros, C. & Garcia-del-Barrio, P. (2008). Efficiency Measurement of the English Football Premier League with a Random Frontier Model. *Economic Modelling, 25,* 994-1002.

Charnes, A., Cooper, W. & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2,* 429-444.

Coelly, T., Prasada Rao, D., O'Donnel, C. & Battese, G. (2005).*An Introduction to Efficiency and Productivity Analysis*. New York: Springer, 242 p.

Cook, D. & Zhu, J. (2015).*Data Envelopment Analysis.* New York: Springer, 364 p.

Cooper, W., Seiford, L. & Tone, K. (2000).*Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA- Solver Software*. Norwell, Massachusetts: Kluwer Academic Publishers, 311 p.

Dawson, P. & Dobson, S. (2002). Managerial efficiency and human capital: an application to English association football. *Managerial and Decision Economics, 23,* 471-486.

Deloitte. (2016).*Deloitte Football Money League 2016.*Direct access: http://www2.deloitte.com/uk/en/pages/sports-business-group/articles/deloitte-football-money-league.html

Espitia-Escuer, M. & García-Cebrián, L. (2004). Measuring the Efficiency of Spanish First-Division Soccer Teams. *Journal of Sports Economics, 5,* 329-346.

Espitia-Escuer, M. & García-Cebrián, L. (2014). Comparison of efficiency measures for Spanish first division football teams using data envelopment and stochastic frontier analyses. *Atlantic Review of Economics, 2,* 66-74.

Espitia-Escuer, M. & García-Cebrián, L. (2015a).*Organisational Design Factors and the Efficiency of Spanish First Division Football Teams.* Direct access: https://zaguan.unizar.es/record/47391/files/texto_completo.pdf

Espitia-Escuer, M. & García-Cebrián, L. (2015b).*Technical progress and efficiency changes in football teams participating in the UEFA Champions League.*Direct access:: https://zaguan.unizar.es/record/47390/files/texto_completo.pdf

Faere, R. & Lovell, C. (1978). Measuring the technical efficiency of production. *Journal of Economic Theory, 19,* 150-162.

Faere, R., Grosskopf, S. & Logan, J. (1983). The Relative Efficiency of Illinois Electric Utilities. *Resources and Energy, 5,* 349-367.

Farrel, M. (1957). The Measurement of Productive Efficiency. *Journal of Royal Statistical Society, 120,* 253-290.

Frick, B. & Simmons, R. (2007). The Impact of Managerial Quality on Organizational Performance: Evidence from German Soccer. *Working Paper Series,3*, 1-20.

Garcia-Sanchez, I. (2007). Efficiency and effectiveness of Spanish football teams: a three- stage-DEA approach. *Central European Journal of Operations Research, 15*, 21-45.

González-Gómez, F. (2010).*Can we be satisfied with our football team? Evidence from Spanish professional football.* Direct access: http://www.ugr.es/~teoriahe/RePEc/gra/wpaper/thepapers08_11.pdf

Guzman, I. & Morrow, S. (2007). Measuring efficiency and productivity in professional football teams: evidence from the English Premier League. *Central European Journal of Operations Research, 15,* 309-328.

Guzman, I. (2006). Measuring Efficiency and Sustainable Growth in Spanish Football Teams. *European Sport Management Quarterly, 6,* 267-287.

Haas, D. (2003). Productive efficiency of English 16. football teams-a data envelopment analysis approach. *Managerial and Decision Economics, 24,* 403-410.

Haas, D., Kocher, M. & Sutter, M. (2004). Measuring Efficiency of German Football Teams by Data Envelopment Analysis. *Central European Journal of Operations Research, 12,* 251-268.

Halkos, G. & Tzeremes, N. (2011). *A non-parametric analysis of the efficiency of the top European football clubs.* Direct access: https://mpra.ub.uni-muenchen.de/31173/1/MPRA_paper_31173.pdf

Jardin, M. (2009).*Efficiency of French football clubs and its dynamics*.Direct access: https://mpra.ub.uni-muenchen.de/19828/

Karaduman, A. (2006).*Data Envelopment Analysis and Malmquist Total Factor Productivity (TFP) Index: An application to Turkish automotive industry*.Direct access: https://etd.lib.metu.edu.tr/upload/12607821/index.pdf

Kern, M. & Süssmuth, B. (2003).*Managerial Efficiency in German Top League Soccer*. Direct access: https://epub.ub.uni-muenchen.de/5/

Koopmans, T. (1951).*An analysis of production as an efficient combination of activities*.London: John Wiley and Sons, 352 p.

Kulikova, L. & Goshunova, A. (2013). Measuring Efficiency of Professional Football Club in Contemporary Researches. *World Applied Sciences Journal, 25,* 247-257.

Kulikova, L. & Goshunova, A. (2014). Efficiency measurement of professional football clubs: a non-parametric approach. *Life Science Journal, 11,* 117-122.

Lukinova, O.A., Smarchkova, L.V. & Pisarenko, N.D. (2014). Assessment and management of social and economic efficiency of activity of economic agents. *Vestnik Samara State University of Economics, 12(122)*, 74-78.

Ribeiro, A. & Lima, F. (2012). Portuguese football league efficiency and players' wages. *Applied Economics Letters, 19,* 599-602.

Soleimani-Damaneh, J., Hamidi, M. & Sajadi, N. (2011). Evaluating the Performance of Iranian Football Teams Utilizing Linear Programming. *American Journal of Operations Research, 1,* 65-72.

Yawe, B. (2010). Hospital Performance Evaluation in Uganda: A Super-Efficiency Data Envelope Analysis Model. *Zambia Social Science Journal, 1,* 153-165.

Zhao, D. (2013). Measuring Technical Efficiency of the Japanese Professional Football.Direct access: http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=6168&context=etd